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AMMONIATION: CHAFF AND OTHER AGRICULTURAL PRODUCTS

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Ammoniation - What is it?

Ammoniation is a method of treating low-quality hay and crop residues such as straw and chaff to improve their nutritional value as feeds for ruminant animals. The method involves sealing the crop residue or hay with a gas-tight cover and adding anhydrous liquid ammonia supplied by fertilizer dealers. After 21 days, treated crop residue is ready to be fed. Piles of cereal chaff can be ammoniated without a cover; however, the product will have a lower nutritional value than chaff ammoniated under a cover.

Persons who intend to ammoniate straw or chaff are strongly advised to contact their Extension or Livestock Agrologist for assistance.

Ammoniation can also be used to preserve high-moisture crop residues and forages. Special precautions must be taken with high-moisture, high-quality forages to prevent the production of toxic ingredients.

Our recent research has focused on the use of ammoniated chaff in maintenance rations for pregnant cows. Since the nutritive value of Saskatchewan chaff is higher than the nutritive value of straw, ammoniated chaff can be used in growing rations and may also be beneficial in finishing rations as well.

Why Ammoniate Chaff?

As noted above, chaff has a higher nutritional value than straw; it may also be less expensive to collect and feed than conventional rations consisting of straw and hay. A system making use of chaff now has the additional agronomic advantage of leaving almost all the straw on the field to help increase organic matter in the soil and decrease soil erosion. Except for some northern Saskatchewan farming areas, the removal of straw on a regular basis could be detrimental to the soil if continued over a period of years.

A considerable saving may be realized if ammoniated chaff is fed instead of hay. A saving can also be realized if ammoniated chaff is fed instead of untreated cereal residues plus grain; however, the amount saved is very dependent on the cost of feed grains. Chaff contains a considerable amount of viable weed seeds and small or shriveled kernels of grain which may germinate the following spring. The saving noted above, can be significantly increased in

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situations where chaff removal can eliminate even one tillage operation in next year's summerfallow. This has been observed by a number of farmers in the Brown and Dark Brown soil zones who were surveyed recently.

Ammoniation improves feeding quality by increasing the amount of digestible energy (TDN) in the residue, the crude protein (CP) content, and the amount of roughage the animal will consume.

In our studies, no incidents of impaction have been observed during the feeding of ammoniated straw or chaff to pregnant cows. However, care was taken to insure that the rations contained sufficient energy, usually in the form of a grain supplement. No abortions, light-weight calves, or reproductive problems have been observed in any of our studies. We are not aware of any studies conducted by other organizations that reveal such problems.

A few toxicity problems have been encountered in Australia, the United States, and Canada during the last few years. They occur when ammonia remains for too long a time at too high a temperature (above 70°C) in contact with a residue or forage which contains soluble sugars. The animals become hyperactive and can harm themselves seriously if they are not taken off this feed immediately. Young calves are much more susceptible to these toxic ingredients than mature cows or heifers.

Recommendations for Ammonia Treatment

A. Ammonia concentration.

- The material to be processed should be exposed to 3 percent ammonia, based on dry matter content, for at least 21 days. Additional exposure time will increase the nutritional value of the residue, but at a much slower rate.

- At temperatures below 10°C, 5 percent ammonia will increase the rate and extent of the improvement in nutritive value more than will 3 percent ammonia, but at an increased cost, which may not be justified.

B. Temperature.

- Since the improvement in nutritive value due to ammonia treatment will decline as the temperature drops below 10°C, it will be advantageous to the producer to conduct the ammoniation as early as possible after harvest to take advantage of higher outdoor temperatures.

- Some producers have added excess water to their chaff piles when the chaff temperature is near or below freezing. This has caused the chaff to begin heating. This heating can only be allowed to continue for 1 or 2 days at most or damage to the nutritive value of the chaff will result. Ammonia can be added as soon as the stack is warm (20°C) to prevent further heating and to react with the chaff. This will improve the reaction as higher crude protein and TDN values can be obtained than were possible at the lower temperatures. Temperatures quite a bit higher than 20°C for a limited period will not necessarily damage the chaff. However, extreme care must be used to prevent the chaff from being irreversibly damaged by an extended period at too high a temperature.

C. Moisture content.

- The optimum moisture content for ammoniating crop residues is 20 percent. The observed improvements in nutritive value from ammonia treatment will be reduced at lower moisture contents. Moisture contents higher than 20 percent do not appear to significantly affect the chemical reaction. Ammoniated residues of 30-35 percent moisture may be more palatable to the animal, but they also render the material more prone to heating and may cause handling problems in winter due to freezing.

D. Exposure Time

- When Katepwa wheat chaff is exposed to 3 percent ammonia at 20°C and 20 percent moisture, the initial reaction which causes an increase in CP content and TDN appears to be fairly rapid. The reaction seems to slow down noticeably after 6 to 15 days exposure, but appears to continue at a very slow rate as long as the ammonia concentration is maintained. Since the reaction conditions on the farm cannot be easily controlled, we recommend that a reaction taking place under plastic be left covered for a minimum of 21 days, but not be uncovered until required for feed.

NB. Details on the effect of ammonia concentration, temperature, moisture con-

tent, and exposure time are included in the APPENDIX.

How to Ammoniate Chaff

1. Sampling Prior to Ammoniation

- The quality of chaff can vary considerably from season to season, from field to field, and even pile to pile taken from the same field. It is therefore necessary to combine small amounts of chaff taken from different parts of the field or from different piles so the analysis will accurately represent your material.

- Seal the sample in a plastic bag to prevent moisture loss and indicate to the Feed Testing Laboratory, University of Saskatchewan, that the material sampled is to be ammoniated and that you require the moisture content of the sample as submitted as well as a measurement of its nutritive quality.

2. Estimating the Weight of Chaff in a Pile

It is always preferable to determine the weight of chaff in a pile by weighing a few truckloads and multiplying the average weight by the number of truckloads in the pile. If this has not been done, the weight of chaff can be roughly estimated as follows:

Width of chaff pile at the base (feet)	=	W
Height of chaff pile (feet)	=	H
Length of chaff pile at the base (feet)	=	L
Density of chaff pile (lbs./cubic foot)	=	D

D = 5 lb./cubic foot before settling
or = 6.5 lbs./cubic foot after settling

$$\textit{Weight of chaff (tons)} = T_P = \frac{(W-6)\,(L-10)\,HD}{2000}$$

eg. W = 25 ft.; H = 9 ft.; L = 95 ft.; D = 5 lb.ft.^{3}.

$$\textit{Weight of chaff} = \frac{(25-6)\,(95-10)\,9 \times 5}{2000}$$

$$= \frac{19 \times 85 \times 9 \times 5}{200} = 36.3$$

3. Adding Moisture

Although it is preferable to know exactly how much moisture is present in the chaff by means of an analysis, this may not be a practical alternative. Chaff obtained from threshing at normal grain moisture, which has not been rained on or covered with snow, will usually contain from 8 to 10 percent moisture. Because the optimum moisture content for an ammoniation is about 20 percent, it is necessary to add moisture to this chaff.

One of the simplest methods of adding moisture is to spray the required amount of water onto each truckload of chaff and mix the chaff well with a front end loader while piling it for treatment. A reasonable estimate of the weight of chaff in a truckload and its moisture content is required. The following method can be used to estimate of the amount of water to add:

Truckload of Chaff

Weight of chaff	= T_t
% Moisture	= M_i
% Moisture to be added = M_a =	23-M_i

Volume of water to be added (gals.)

$$= \frac{M_a \times T_t}{1000}$$

eg. Weight of truckload of chaff (T_t)
= 2 tons (4000 lbs.)
Moisture (M_i) = 8%
% Moisture to be added (Ma) = 23 - 8 = 15%

Volume of water to be added =

$$\frac{15 \times 4000}{1000} = 60\,gal.$$

Another method of increasing the moisture content is to pile the chaff and inject a calculated amount of water into each approximately 2 foot square (4 square feet) of upper surface through a perforated pipe. This will spread out the moisture as much as is practically possible. A reasonable estimate of the weight of chaff and its moisture content is also required. Use the following method to estimate the amount of water to add:

Pile of Chaff

Weight of chaff in the pile	= T_p
% Moisture	= M_i
% Moisture to be added (M_a) =	23 - M_i

Volume of water to be added =

$$\frac{M_a \times T_p}{1000}$$

eg. Weight of chaff in the pile (T_p) =
40 tons (80000 lbs.)
% Moisture (M_i) =10%
% Moisture to be added (M_a) = 23 - 10 = 13%

Volume of water to be added =

$$\frac{13 \times 80000}{1000} = 1040\,gal.$$

A pile of chaff measuring 95 feet by 25 feet would have an upper surface area of approximately 80 feet by 18 feet or 1440 square feet.

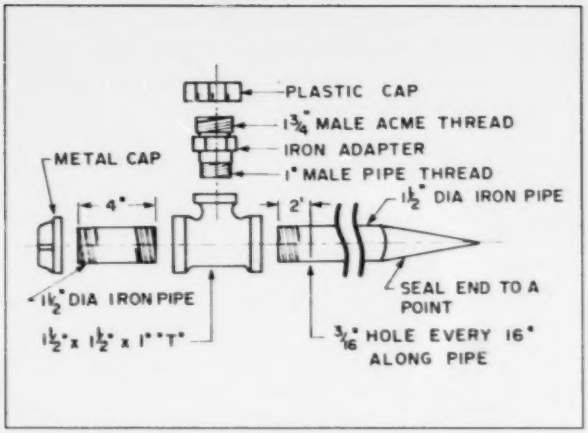

Figure 1. Ammoniation pipe with fittings

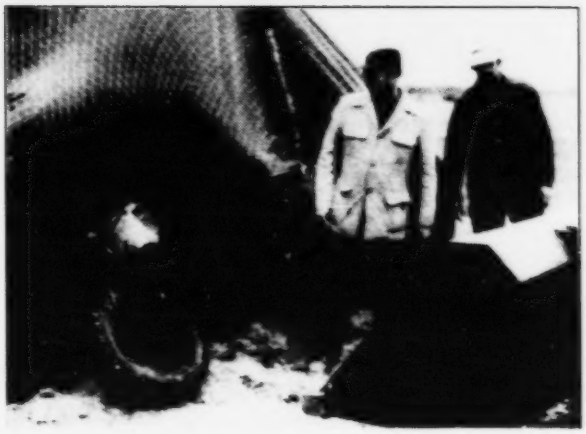

Figure 2. Inserting pipe into chaff pile.

Each 2 foot square will require

$$\frac{1040}{1440/4} = 2.9\,gal.$$

Each 3 foot square will require

$$\frac{1040}{1440/9} = 6.5\,gal.$$

(The 2 foot square would spread out the moisture better than the 3 foot square but will require more time and effort.)

4. Covering the Pile of Chaff

A sheet of black polyethylene 100 feet by 40 feet will cover a chaff pile 95 feet in length, 25 feet wide and about 10 feet high. A pile this size would contain approximately 40 tonnes of chaff. The plastic can be pulled over the pile and sealed about the perimeter with soil, sand, or gravel. If a time is chosen to do this job when there is very little wind, three people can cover and seal a chaff pile in less than one hour. Chaff can be ammoniated without a cover, although the improvements in crude protein content and digestibility will not be as good and will depend on the size of the chaff pile. If this method is to be used, it is advisable to soak the surface of the pile with water before adding the ammonia. This tends to trap escaping ammonia and cause the surface of the pile to crust over a little, providing some wind protection. Some types of chaff, such as canola chaff, do not pack well. These must be covered to retain the ammonia unless they are mixed with cereal chaff.

5. Preparing and Inserting Ammoniation Pipes

We recommend using only iron pipes for adding ammonia to the chaff. Iron pipes about 22 feet long and 1 1/2 inches in diameter are sealed to a point at one end and threaded on the other. (Pipes 1 1/4 inches in diameter may be suitable, but pipes 1 inch in diameter are not.) A 1 1/2 inch by 1 1/2 inch by 1 inch "T" containing a 4 inch length of 1 1/2 inch pipe, threaded on both ends and capped, is screwed onto the end of the pipe as shown in Figure 1. An iron adapter with a 1 inch male pipe thread on one end and a 1 3/4 inch male acme on the other is screwed into the "T" and fitted with a plastic cap. The 1 3/4 inch male acme[1] will fit the valve on the ammonia hose. Beginning about 2 feet from the "T", drill 3/16 inch holes every 16 inches along the length of the pipe on the side opposite the adapter (Figure 1). The pipe is pushed into the pile with a tractor (Figure 2) and adjusted so the holes point down, enabling the pipe to drain free of liquid ammonia.

The pipes are inserted by pushing them into the side of the pile of chaff with a tractor at 6 foot intervals. The pipes should be placed about 2 feet above the ground and be at a slight slope into the pile so ammonia will flow away from the adapter. When ammoniating chaff, there is no need to use a plastic sleeve or to seal the pipe at the point of insertion since ammonia will not escape from the chaff pile quickly. Make sure that the hole in the pipe nearest the adapter is well into the chaff pile.

1 These adapters are available with pipe threads other than 1 inch but the 1 inch size is most common. This adapter must not be brass.

Figure 3. The ammonia dealer attaches the valve on the end of the ammonia hose to the acme adapter on the "T" of the ammonia pipe.

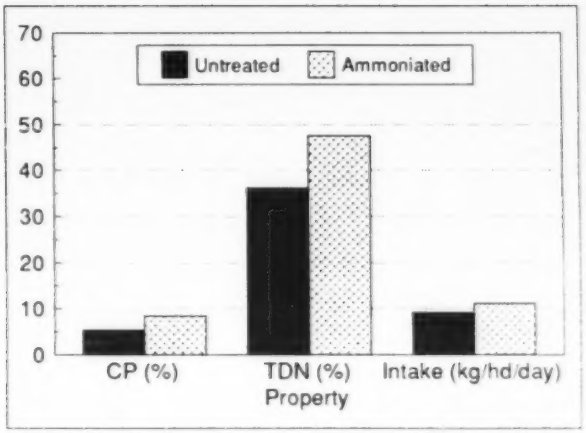

Figure 4. Effect of ammonia on the crude protein (CP) content, total digestible nutrients (TDN), and animal intake of Katepwa wheat chaff.

6. Determining How Much Ammonia to Add

We recommend adding 3 percent anhydrous ammonia based on the dry matter content of the residue. Calculate the total volume of ammonia to add and the volume per pipe as follows:

Weight of chaff in the pile = T_p
% moisture = M_i
Volume of ammonia to be added
$= 0.426T_p(100 - M_i)$

eg. Weight of chaff in the pile (T_p) = 38 tons
% Moisture (M_i) = 20%
Number of pipe insertions (N) = 11

Volume of ammonia to be added to the pile

$= 0.426 \times 38 \times (100 - 20)$
$= 0.426 \times 38 \times 80 = 1295$ litres

Volume of ammonia per pipe = 1489/11 = 118 litres

Clearly, the more accurate the measurement or estimate of the amount of your chaff in the pile and of the moisture content, the more accurately you can calculate the amount of ammonia required.

7. Adding the Ammonia

Now that the stacks have been covered and the pipes inserted, treatment can begin. PRESSURIZED, LIQUID, ANHYDROUS AMMONIA IS VERY HAZARDOUS. THIS OPERATION SHOULD BE CARRIED OUT BY AN EXPERIENCED AMMONIA DEALER (Figure 3).

It is important to add the correct amount of ammonia: too much means unnecessary expense; too little means poorer quality feed. Since it is difficult to measure the amount of anhydrous ammonia being delivered from a nurse tank, adding from a metered pump will assure that you do not over- or under-ammoniate your chaff.

Very likely, you will not have a sufficient number of pipes to have one in each position before starting to add ammonia. Therefore, you will have to move them to new positions fairly soon after their use to not delay the operation. After ammonia has been added through a pipe, allow the pipe to drain for a about 5 minutes before attaching a chain and pulling it out of the pile with a truck or tractor. MAKE SURE THAT PERSONS HANDLING THE PIPES ARE WEARING ADEQUATE SAFETY CLOTHING, PARTICULARLY GOGGLES AND GLOVES.

8. Uncovering Piles of Ammoniated Chaff

Uncovering piles of ammoniated chaff is not as critical as uncovering stacks of baled, ammoniated straw, where care must be taken about wind direction and avoiding exposure. With chaff much of the free, unreacted ammonia will be retained in the chaff pile for a considerable time. However, it is still advisable to open the pile on a day when there is a light breeze blowing away from buildings and corrals. Remove the cover by pulling it into the wind, so that what ammonia gas is released will be blown away from you.

9. Feeding Ammoniated Chaff

Wheat chaff has a fairly good feeding value for a cereal crop residue. Untreated wheat chaff has a CP content of about 4.5 percent and a TDN of 35 to 42 percent without taking the weed seed and grain content into consideration. As well as improving the CP and TDN content of the chaff itself (Figure 4), ammonia treatment of chaff renders the weed seeds and grain non-viable. Another very important improvement is that the animal intake of chaff is substantially increased by ammonia treatment (Figure 4). Some

types of rough awned chaff are very difficult for sheep and cattle to ingest. Ammoniation of these increases the intake and eliminates problems animals encounter from consuming them.

Ammoniated chaff can be fed by any method commonly used by producers. One of the simplest, easiest, and least expensive methods is to feed directly from the side of the pile using an electric wire to maintain even consumption. Once cattle become accustomed to an ammoniated ration, they can tolerate a considerable amount of free ammonia and it is not necessary to aerate the chaff prior to feeding.

Formulating the Ration

The Saskatchewan Feed Testing Laboratory will analyze your ammoniated chaff and formulate the appropriate maintenance ration for cows. The cost* is $30.00 per sample for moisture, crude protein, and an in vitro organic matter digestibility to determine the digestible energy. Submit a representative sample of the ammoniated chaff and indicate what other ingredient (e.g. oats) you have available to include in the ration, at least during cold periods. Ideally, you should submit a representative sample of the other ingredient, so that its feed value can be accurately determined. WARNING: DO NOT FEED SUPPLEMENTS CONTAINING UREA WITH AMMONIATED RESIDUES. THE COMBINATION MAY BE TOXIC TO ANIMALS.

Collecting Chaff

The collection of chaff may present some problems to the producer during combining. However, most producers who have collected chaff for several years claim that these problems are minimal. On the other hand, chaff collection has numerous advantages. It removes a crop residue from the field which has crop-retardation properties and which contains viable weed seeds and shriveled and broken kernels of grain which would otherwise be spread back onto the land. A recent survey of 50 farmers who collect chaff indicates that continual removal of chaff containing weed seeds and shriveled kernels of grain may reduce future herbicide and/or tillage requirements. When only the chaff is collected, the straw left on the surface will help reduce erosion; and when worked into the soil, the straw will help maintain organic matter content.

Methods and equipment have been developed which have now turned chaff collection into an efficient operation. (Chaff collection will be discussed in detail in another bulletin.) Chaff can be collected at a cost of from $10.00 per tonne to $25.00 per tonne depending on the amount required and the equipment being used.

The Bottom Line – Costs and Benefits

Costs of Ammoniation

The cost of treating chaff with ammonia is, of course, dependent on the cost of materials. The cost of plastic (40 feet by 100 feet, 6 mil., black polyethylene) varies from $120.00 to $185.00 per roll depending on where and when you buy it. The cost of anhydrous ammonia has remained fairly stable for several years and is approximately $400.00 per tonne. Again, this cost depends on where and when you order it.

At this price, the cost of ammonia to treat 1 tonne of chaff originally containing 10% moisture, would be $10.50. The cost for plastic depends on the weight of chaff being covered. Covering 40 tonne of chaff with plastic costing $160.00 per roll would come to an additional $4.00 per tonne, or a total of $14.50 per tonne of chaff. These are strictly out-of-pocket costs and do not include the cost of the pipes, machinery, or labour. If we include all costs for the ammoniation of 3 40-tonne piles of chaff, the total would be $16.25 per tonne. Some of these costs are capital costs and will vary considerably with the total amount of chaff processed.

Costs of Feeding Ammoniated Rations

Feeding ammoniated rations can only be an advantage when the increased intake and digestibility will replace a more expensive supplement. During the past few years when the cost of feed grain was very low, there were instances when it was not an economical advantage to ammoniate except for the preservation of high moisture feedstuffs. The nutritional value of ammoniated chaff depends greatly on the nutritional value of the chaff before treatment, and this is subject to extreme variation. The feeding cost depends on the monetary value you place on your chaff (possibly only the collection cost) as well as the cost of the ammonia treatment.

A trial was conducted several years ago which established intakes of brome-alfalfa hay, ammoniated straw plus supplement, and ammoniated chaff plus supplement. The feeding cost for hay per head per day was $0.80 at a hay price of $80.00 per tonne. For the ammoniated chaff ration valued at an ammoniation cost of $16.00 per tonne and a collection cost of

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* $30.00 is the cost for these analyses in August 1989. This price is subject to change at any time.

$18.00 per tonne, the feeding cost per head per day was $0.46. The difference of $0.34 per head per day between ammoniated chaff and brome-alfalfa hay would amount to a saving of $4,215.00 for an average herd of 67 cows maintained for 185 days.

The ammoniated straw ration was intermediate between these two and cost $0.68 per head per day based on a straw value of $35.00 per tonne. Compared to the ammoniated straw ration, the ammoniated chaff ration realized a saving of $2,725.00 for the same herd for the same maintenance period. This does not take into account any savings which might be realized by removing the chaff from the land and leaving the straw.

Ammoniating Bales of Straw or Low Quality Hay

When ammoniating bales (either round or rectangular) of straw or low quality hay, such as slough hay, you must seal the stack in plastic in order to maintain ammonia concentration during the reaction period. The material should have a moisture content approaching 20 percent in order to achieve maximum improvement. (Water can be added to round bales, but it is very difficult to increase the moisture content of rectangular bales).

Pipes, similar to those described previously, are inserted into each end of the stack, and must be sealed to the plastic cover by using our specially designed sleeve (available from the Saskatchewan Research Council at cost of $5.00 each) or by taping the plastic to the pipe. If this is not done, too much ammonia will escape at the pipe entrance to permit the ammonia dealer to complete the addition. Half the required amount of ammonia should be added to each end of the stack.

Preservation and Improvement of High Moisture Feeds

When the moisture content of forages, crop residues or grain is too high they will begin to heat. The heating is caused by fungal activity, and if it is not stopped soon the material will spoil. Ammonia is a good fungicide and will prevent spoiling if applied properly.

Chaff

If ammonia must to be added to high moisture chaff to preserve it, you might as well add 3 percent ammonia and achieve a good improvement in nutritive value as well. There has been at least one case of hyperexcitability (bovine bonkers) reported due to feeding chaff ammoniated under high moisture conditions. If high moisture, good quality chaff is treated with ammonia while it is very hot, there is a possibility of producing a toxic substance, and the herd should be watched carefully for early symptoms of hyperexcitability. If such symptoms are observed, take the animals off the feed immediately, and they will not suffer any permanent harm. If the moisture content is between 30 and 40 percent, the pipes must be placed only 4 feet apart instead of the normal 6 feet. The high moisture content restricts the horizontal flow of ammonia, and molding may occur between pipes placed 6 feet apart. Heating should have stopped, and the pile should have started to cool, about 24 hours after the ammonia has been added. If this has not occurred, contact your Extension Agrologist immediately. Further action must be taken quickly if the agricultural material is to be saved. Chaff piles do not have to be covered with plastic to accomplish preservation and to improve the nutritive value, although better improvement and longer storage time will be achieved if the pile is covered.

Bales of Straw and Low Quality Hays

The same approach applies to straw and low quality hays as applies to chaff as far as getting an improvement in nutritive value. However, the stacks must be covered to get the maximum improvement. Individual round bales can be preserved by adding anhydrous ammonia to each bale separately without covering. Apparently, the ammonia first stops the heating, then escapes from the bale taking quite a lot of moisture with it. The resulting bale is left sufficiently dry to resist further spoilage. For preservation, 1 percent ammonia is sufficient to stop heating in forage containing 25 to 30 percent moisture, but 2 percent is necessary to stop heating in bales containing 30 to 50 percent moisture.

Bales of High Quality Forage

These bales can be preserved in the same way bales of straw can be preserved. It will not be necessary to add 3 percent ammonia since these materials are highly nutritious and would not improve much. Caution: Ammonia will react with soluble sugars at temperatures above 70°C to form a toxic ingredient which can cause hyperexcitability in cattle. Young calves appear to be much more sensitive to this compound than mature cows. Since high quality forages and green feed are much more likely to contain soluble sugars than lower quality materials, care should be taken not to treat these materials with more than 1 or possibly 2 percent ammonia.

Grain

If high moisture grain cannot be ensiled to preserve it, it can be preserved with anhydrous ammonia. Adding ammonia to grain in a pile or in a granary by inserting a pipe does not produce satisfactory results. Ammonia can be best applied to grain

by means of a "Cold-Flo" converter as the grain is being conveyed through an auger into a granary or to a pile on the ground. The "Cold-Flo" converter cools the liquid ammonia below its boiling point so it is no longer under pressure. Since ammonia will react with galvanized metal during storage, the interior of galvanized bins must be sealed with epoxy.

Safety Considerations

Be sure to observe all the safety precautions noted in this publication.

The anhydrous ammonia pumped into your material is in liquid form, under moderate pressure. It is VERY TOXIC to the skin and eyes. If you should come into contact with anhydrous ammonia, flush it away immediately with water or serious injury will result. As it is added to the stack, liquid anhydrous ammonia evaporates, forming a gas with a pungent and disagreeable odour. Exposure to concentrations of this gas higher than 100 ppm can be dangerous. Build your stacks or piles sufficiently far apart and organize the work to avoid excessive exposure to the gas.

Mixtures of 16 to 27 percent ammonia in air can be flammable and even explosive. Concentrations in this range may be encountered immediately following the addition of ammonia to the residue. Depending on the humidity, temperatures of 500°C or higher are required for ignition. The duration of time the concentration remains in the dangerous range depends on the moisture content of the straw, and is shorter at higher moisture contents. As a safety precaution, never smoke or light a flame near ammonia.

Remember to insert the pipes into the pile of chaff or stack of straw or hay about 2 feet above the ground, slanting slightly into the roughage, and with the holes on the bottom so the pipes will drain free of ammonia. This will reduce the possibility of injury.

Acknowledgement

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APPENDIX

HOW TO GET THE BEST IMPROVEMENT BY AMMONIATING CHAFF

The treatment of chaff with ammonia will increase its crude protein (CP) content. A portion of this added CP can be utilized by the animal. The treatment also solubilizes part of the fibre and swells the remaining material, enabling more cellulose to be digested in the rumen. When chaff is treated with ammonia, a chemical reaction takes place which is affected by the conditions existing during the duration of treatment. The four most important factors are:

- ammonia concentration,
- temperature of the reaction mixture,
- moisture content,
- exposure time of the reaction.

The following four figures show that the improvement of the chaff in CP content and total digestible nutrients (TDN) is increased as the ammonia concentration increases from 1 to 5 percent (based on the dry matter content of the chaff), as the temperature is increased from -20°C to +30°C, as the moisture content is increased from 5 to 20 percent, and with time.

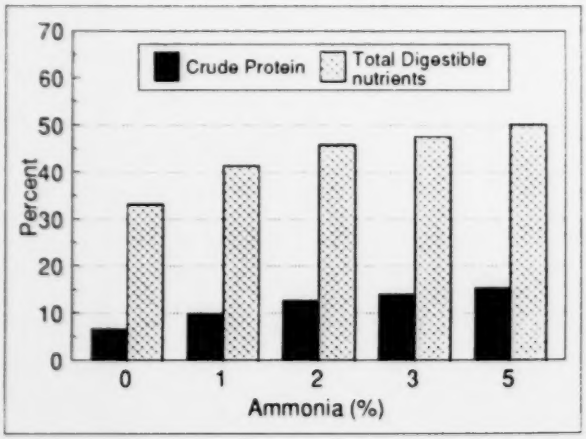

Figure 1. The effect of ammonia concentration on

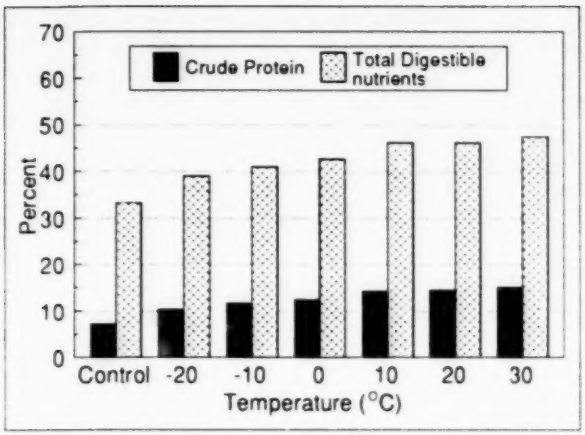

Figure 2 The effect of temperature on the crude protein (CP) content and the total digestible nutrients (TDN) of Katepwa wheat chaff.

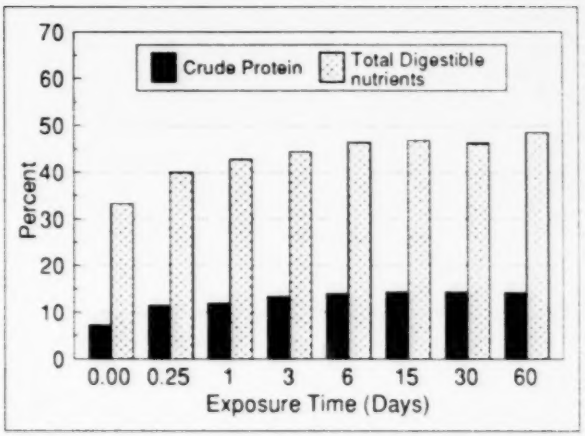

Figure 4. Effect of time of exposure to ammonia on the crude protein (CP) content and total digestible nutrients (TDN) of Katepwa wheat chaff.

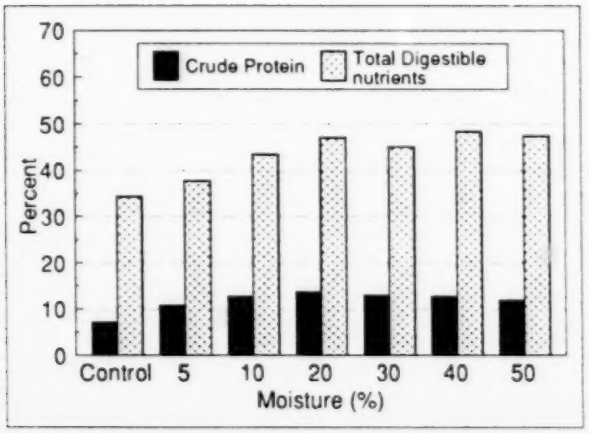

Figure 3. The effect of moisture on the crude protein (CP) content and the total digestible nutrients (TDN) of Katepwa wheat chaff.

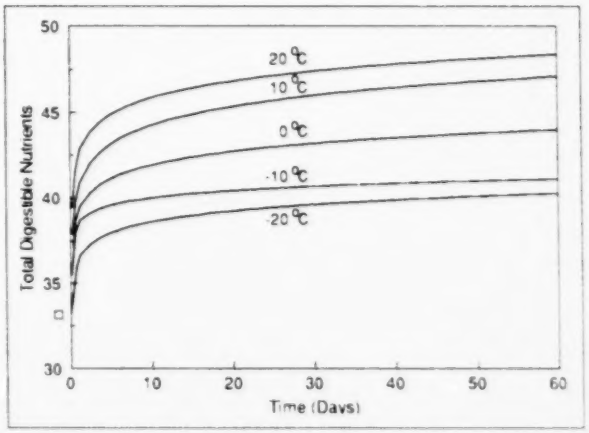

Figure 5. Effect of time of exposure to ammonia on the total digestible nutrients (TDN) of Katepwa wheat chaff.

1. Ammonia concentration. (Exposed at 20C and 20 percent moisture for 21 days.)

Both CP and TDN increase directly with the ammonia concentration (Figure 1). The lower concentrations (1 and 2 percent) do improve the feed value of chaff to some extent but are mainly used for the preservation of high moisture crop residues and forages. We recommend the use of 3 percent ammonia to enhance nutritional value. Higher concentrations (eg., 5 percent) increase both the rate and extent of the reaction, and may be used under certain circumstances (late fall when the ambient temperature is very low); however, this use may not be justified economically.

2. Temperature. (Exposed at 3 percent ammonia and 20 percent moisture for 21 days.)

As shown in Figure 2, the effect of ammoniation is considerably reduced at temperatures below the freezing point, and is not increased significantly by temperatures above 20°C.

3. Moisture content. (Exposed at 3 percent ammonia and 20°C for 21 days.)

Although some improvement in CP content and TDN is observed at 5 percent moisture (Figure 3), the maximum improvements are obtained at 20 percent moisture. Therefore, we recommend increasing the moisture content to at least 20 percent before treating with ammonia.

4. Exposure Time (Exposed at 3 percent ammonia, 20°C, and 20 percent moisture)

The rate of improvement in CP and TDN is quite rapid during the first few days exposure. It appears to level off after about 15 days, although some improvement is still taking place (Figure 4). Since practical farm conditions cannot be controlled as they can in the laboratory, we recommend letting the reaction continue for at least 21 days. The reaction appears to continue indefinitely after 21 days, but at a much slower rate.

Leaving the chaff pile exposed to ammonia for an extended length of time does improve its TDN and CP content. However, as shown in Figure 5 the rate of improvement in TDN after 21 days exposure is so slow that the improvement may never be equivalent to that achieved after 21 days exposure at 20C.

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